Kentucky Method 64-322-02
Revised (not applicable)
Supersedes (not applicable)
Dated (not applicable)

ESTIMATING CONCRETE STRENGTH BY THE MATURITY METHOD

1. SCOPE:

1.1. This method is a modification of ASTM C 1074 covering the procedures for estimating concrete strength by means of the maturity method.

1.2. The maturity method may be used for opening concrete pavement to traffic. This method may be used for Class P, PCCP/24, PCCP/48, and PCCP/72.

1.3. A relationship must be established between the maturity values and the concrete strength as measured by cylinder testing. The development of the maturity-strength curve shall be performed using project materials and the proposed concrete mix design. The contractor shall be responsible for the development of the maturity curve. The District Materials Engineer shall monitor the curve development. The temperature monitoring process of the constructed pavement shall be the responsibility of the contractor and shall be monitored by the Engineer. Determining that sufficient strength has been achieved shall remain the responsibility of the Engineer. Acceptance of the concrete shall be based upon the 28-day cylinder strength.

1.4. Changes in material sources, proportions, admixtures, and mixing equipment all affect the maturity value of a given concrete mixture. Therefore, development of a new maturity curve is required for any change to a concrete mix unless the District Materials Engineer deems otherwise.

2. APPARATUS:

A device is required to monitor and record the concrete temperature as a function of time. Use a commercial maturity instrument that automatically computes and displays the temperature-time factor (TTF).

3. MATURITY FUNCTIONS:

3.1. There are two alternate functions for computing the maturity value from the measured temperature history of the concrete; the Nurse-Saul equation and the Arrhenius equation. The Department uses the Nurse-Saul equation.

3.2. The maturity function, known as the Nurse-Saul equation, is used to compute the TTF as follows:

$$M(t) = S(T_a - T_o) \Delta t$$

where:
- $M(t)$ = the TTF at age t, degree-days or degree-hours,
- Δt = a time interval, days or hours,
- T_a = average concrete temperature during time interval, Δt, °C, and
- T_o = datum temperature = -10 °C.

4. PROCEDURE TO DEVELOP STRENGTH-MATURITY RELATIONSHIP:

4.1. Prepare at least 15 cylindrical specimens according to Kentucky Method 64-305. The mixture proportions and constituents of the concrete shall be the same as the concrete whose strength will be estimated using this practice. The concrete shall be produced using the same equipment as that which will produce concrete for the project. The cylinders may be cast at the concrete plant or the job site. Since there is a direct relationship between the w/c (water/cement) ratio and strength, the concrete used to develop the maturity-strength relationship shall be at the maximum w/c ratio expected during production.

4.2. Embed temperature sensors in the centers of at least two cylinders. Connect the sensors to one or more maturity meters. Use the average of the readings to develop the maturity-strength curve.

4.3. Moist cure the specimens in a water bath or in a moist room meeting the requirements of KM 64-305.

4.4. Perform compression tests at five different ages. Test three specimens at each age and compute the average strength. If a low test result is due to an obviously defective specimen, discard the low test result. The tests shall be spaced such that they are performed at somewhat consistent intervals of time and span a range in strength that includes the opening strength desired. The table below gives suggested test times. Test 3 is the target test. This is only a guide and may need to be modified depending on specific mixtures and conditions.

APPROXIMATE TEST TIMES

Mix (strength psi)	Test 1	Test 2	Test 3	Test 4	Test 5
Class P	2 days	3 days	4 days	5 days	6 days
Class PCCP/24	6 hours	10 hours	12 hours	14 hours	24 hours
Class PCCP/48	24 hours	36 hours	48 hours	60 hours	72 hours
Class PCCP/72	48 hours	60 hours	72 hours	84 hours	96 hours

4.5. At each test age, record the average maturity value for the instrumented specimens.

4.6. Use the spreadsheet provided by the Department to determine the maturity-strength relationship. This spreadsheet can be found on the Materials Web Page at www.kytc.state.ky.us/materials/material.htm. The

TTF number corresponding to the desired compressive strength shall be used to determine when the concrete has reached desired strength.

4.7. The computed R^2 value obtained from regression analysis of the maturity-strength relationship shall be 0.95 or higher. The R^2 value can be found on the maturity curve chart. When R^2 value is below 0.95 the curve is unacceptable and a new curve will be required.

5. PROCEDURE TO ESTIMATE IN-PLACE STRENGTH:

5.1. Insert temperature sensors at mid-depth of the pavement and a minimum of 12 inches from the edge of the concrete. They should be placed in the plastic concrete as soon as possible. Avoid placing the sensors near reinforcing steel. A threaded rod with a wing nut may be used to insert the sensors in the pavements and immediately removed. Consolidate the concrete around the sensor as needed. The rod can be marked for various insertion depths. This device will allow the placement of the sensors with minimal disturbance to the concrete. Sensors should be placed in the concrete where the temperatures are expected to be the coolest.

5.2. For a normal day production, randomly place 2 sensors to determine the maturity. They shall be located in the last 100 feet of pavement placed.

5.3. Connect the sensors to maturity instruments and activate the recording devices as soon as is practicable.

5.4. When the strength at the location of a sensor is to be estimated, read the maturity value from the instrument. The strength of the concrete can be determined from the spreadsheet or calculated from the curve equation.

6. VALIDATION:

6.1. Conduct field validation on the first day of production. Validation shall consist of testing a set of 3 cylinders near the TTF value for the required strength to determine if the concrete is represented by the current maturity curve.

6.2. Test for air, slump, and temperature. Cast a set of 3 cylinders at the job site. Place a sensor at mid point of a cylinder and connect it to a meter. Field cure cylinders made for validation in accordance with KM 64-305.

6.3. If the cylinder strength is equal to or above the original maturity curve, the curve is considered validated and validation shall be conducted weekly thereafter. A value that is more than 10% below the expected strength is unsatisfactory and a new curve is required. If 3 consecutive tests fall between 0% and 10% below the curve, a new curve is required.

References:

Iowa Department of Transportation, “Method of Testing the Strength of Portland Cement Concrete Using the Maturity Method”, 1997.

Indiana Department of Transportation, “Strength of Portland Cement Concrete Pavement (PCCP) Using the Maturity Method, ITM 402-99T”, 1999.

Mohsen, J. P., Kessinger D. T., Roach, B. L., “Maturity Method Applied to Highway Construction – The Kentucky Experience”, 2001. Transportation Research Board Meeting, 2001.

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